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(71) Applicant *(for all designated States except US)*: **BLIS TECHNOLOGIES LIMITED** [NZ/NZ]; Level 10 Otago House, 481 Moray Place, Dunedin (NZ).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: **CHILCOTT, Christopher, Norman,** [NZ/NZ]; 55 Silverton Street, Andersons Bay, Dunedin (NZ). **TAGG, John, Robert,** [AU/NZ]; 39 Braeview Crescent, Dunedin (NZ).

(74) Agents: **GRIFFITHS, Teresa V** et al.; A J Park, 6th Floor Huddart Parker Building, 1 Post Office Square, PO Box 949, 6015 Wellington (NZ).

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(54) Title: ANTIMICROBIAL COMPOSITION

(57) Abstract: This invention provides novel Streptococcus salivarius, compositions containing same, and use of S. salivarius strains as antimicrobial agents. The strains are bacterial inhibitors with respect to at least S. mutans and/or MS and therefore have a number of therapeutic applications. The applications include but are not limited to forming part of therapeutic formulations for use in controlling, treating, or preventing dental caries.

ANTIMICROBIAL COMPOSITION

FIELD OF THE INVENTION

This invention relates to novel *Streptococcus salivarius*, compositions containing same, and use of *Streptococcus salivarius* strains as antimicrobial agents, particularly in the prevention or treatment of dental caries.

BACKGROUND

Dental caries is a disease characterised by dissolution of the mineral portion of the tooth. As caries progresses, destruction of tooth enamel and dentine occurs followed by inflammation of pulp and periapical tissues.

The mutans streptococci (MS) are a cluster of acidogenic, dental plaque-inhabiting streptococcal species that are considered the principal causative agents of caries. Presently, seven different MS species (known as *S. mutans, S. rattus, S. cricetus, S. sobrinus, S. ferus, S. macacae,* and *S. downei*) are recognised. Of these seven species it is mainly *S. mutans* and *S. sobrinus* that are of significance in terms of human caries.

Over the years various methods have been developed and tried with varying results, to prevent or at least alleviate the problem of dental caries. Treatments with antibiotics such as penicillin have been suggested and are effective but indiscriminately destroy both useful and harmful bacteria in the mouth leading to microbial imbalances.

In order to minimise disruption to the mouth microflora, antibiotic producing organisms have been investigated for their ability to inhibit caries. A group of organisms identified as having potential in this regard are microorganisms producing bacteriocin-like inhibitory substances (BLIS). BLIS producers of the genera *Streptococcus*, *Staphylococcus* and *Enterococcus* have been screened for potential application to prevention of dental caries (Balakrishnan, M. et al., Caries Res. 2001; 35:75-80).

What is sought is a non-virulent analog of the disease-causing *S. mutans*, or a so called effector strain. To serve as an effector strain in replacement therapy in bacterial infection, the microorganism must be non-virulent itself and able to compete successfully with the pathogenic microorganism either via competitive action and/or antibiotic action. *S. mutans* effector strains have been identified (Hillman et al., J Dent Res. 1987; 66:1092-4; James and Tagg, N Z Dent J. 1991; 87:80-3) and show strong anti-*S. mutans* activity. A disadvantage with the use of *S. mutans* effector strains is the cariogenic potential of these strains.

S. salivarius is an alternative streptococcus species which avoids this disadvantage. In WO 01/27143 *S. salivarius* strains are identified which have utility in the treatment of dental caries caused at least in part by *S. sobrinus*. No activity was recorded against MS generally or *S. mutans* in particular. Similarly, in Balakrishnan (supra), *S. salivarius* K3 is identified as active against *S. sobrinus* when grown on trypticase soy broth yeast extract calcium carbonate agar medium, but had no effect on *S. mutans*.

S. salivarius TOVE-R (Tanzer, J.M. et al.; Infect Immun., 1985, 48:44-50) is an antagonist strain and which brought about a reduction in dental caries. There have been no reports of BLIS production by this strain.

The applicants have now identified BLIS-producing *S. salivarius* strains with a broad spectrum of activity against MS dental caries causing organisms including *S. mutans*.

The present invention is broadly directed to these novel *S. salivarius* strains, and the use of anti-MS *S. salivarius* strains in the treatment of dental caries, or at least provides the public with a useful choice.

SUMMARY OF THE INVENTION

Accordingly, in one aspect, the present invention may broadly be said to consist in a biologically pure culture of a *Streptococcus salivarius* strain which is a *Salivaricin* A_2 producer and which exhibits anti-MS activity, with the proviso that the strain is not *S. salivarius* K12 (K12).

In another aspect, the invention provides a biologically pure culture of a *Streptococcus salivarius* strain which is a *Salivaricin A_2* producer, exhibits anti-MS activity, and for carbohydrate metabolism is positive for at least one of L-arabinose, inulin, glycogen, xylitol, and β-gentiobiose use, or β-galactosidase production; and/or is negative for at least one of glycerol, α-methyl-D-mannoside use, or alkaline phosphoaase production.

Preferably, the strain is positive for each of L-arabinose, inulin, glycogen, xylitol, and β-gentiobiose use, or β-galactosidase production; and/or is negative for each of glycerol, α-methyl-D-mannoside use, or alkaline phosphatase production.

The invention further provides a biologically pure culture of *Streptococcus salivarius* strain Mia on deposit at Deutsche Sammlung von Mikroorganismen Und Zellkulturen GmbH, Mascheroder Weg 1 b, D-38124, Braunschweig, Germany, Accession No. DSM 14685, or a culture having the identifying characteristics thereof.

The invention also provides an extract obtainable from *Salivaricin* A_2-producing strains of *S. salivarius*, which extract has anti-MS activity. In particular, the extract has anti-*S. mutans* activity. Conveniently, the extract is obtainable from *S. salivarius* strains Mia or K12.

In a further aspect, the present invention provides an antibacterial composition which includes an *S. salivarius* or extract as defined above.

In a still further aspect, the present invention provides a therapeutic formulation comprising an *S. salivarius* or extract as defined above, together with a diluent, carrier and/or excipient.

In one embodiment, the composition or formulation further comprises a secondary antibacterial agent.

In one embodiment, the therapeutic formulations are in the form of foods or drinks, preferably in the form of a dairy product-based food or drink. Alternative forms are medicaments, lozenges and confectionaries.

The invention further provides a method for at least inhibiting the growth of bacteria sensitive to *S. salivarius* of the invention, the method comprising contacting the sensitive bacteria with

an inhibitory effective amount of an *S. salivarius*, extract or composition or formulation of the invention.

Preferably the sensitive bacteria are MS, and more preferably *S. mutans*.

The invention provides in another aspect a method for at least inhibiting the growth of MS or *S. mutans*, the method comprising contacting the MS or *S. mutans* with an inhibitory effective amount of:

(i) an *S. salivarius* extract composition or formulation of the invention; or

(ii) *S. salivarius* K12 or an anti-MS or anti-*S. mutans* active extract therefrom, or a composition or formulation comprising K12 or an active extract therefrom.

In a further aspect, the invention provides a method of prophylactic or therapeutic treatment of dental caries caused at least in part by *S. mutans* in an individual in need thereof, the method comprising administering to said individual:

(i) an *S. salivarius*, extract, composition or formulation of the invention; or

(ii) *S. salivarius* K12 or an anti-*S. mutans* active extract therefrom, or a composition or formulation comprising K12 or an active extract therefrom,

in an amount effective to at least inhibit growth of *S. mutans* in the oral cavity of the individual.

In a further aspect, the invention provides a method of controlling the incidence and severity of dental caries comprising introducing into the oral cavity of an individual susceptible to dental caries, a dental caries controlling amount of an *S. salivarius*, extract, composition or formulation of the invention.

In one embodiment the dental caries is caused by MS. In that instance, *S. salivarius* K12 or an anti-MS active extract, or composition or formulation containing same may also be used.

Preferably, *S. salivarius* is administered as part of a food, drink or nutraceutical.

The methods of the invention may include the preliminary step of pre-treating the individual to at least reduce the normal microflora already present.

The invention also relates to the use of *S. salivarius* or extracts of the invention in the compositions and methods discussed above.

In another aspect, the invention also relates to the use of *S. salivarius* strains (including K12) and active extracts in the methods discussed above for inhibiting, controlling, preventing or treating dental caries caused at least in part by *S. mutans*, and more usually by MS.

Although the invention is broadly as described above, it will be appreciated by those persons skilled in the art that the invention is not limited thereto but also includes embodiments of which the following description gives examples.

DETAILED DESCRIPTION OF THE INVENTION

As noted above, the present invention is directed in a first aspect to *Streptococcus salivarius* strains which produce Salivaricin A_2 and which exhibit anti-MS activity. When grown on TSBCaYE agar, the *S. salivarius* strains desirably exhibit activity against a broader spectrum of MS including *S. mutans*. *Salivaricin* A_2 and an A_2-producing *S. salivarius* strain (strain K12) are described for example in WO 01/27143 incorporated herein by reference.

In one embodiment the invention is directed to *S. salivarius* strain Mia and *S. salivarius* strains having the identifying characteristics thereof.

Strain Mia is distinct from strain K12 in its biochemical characteristics as determined using API 20 Strep kit (bioMérieux) and API 50 CH (bioMérieux) which allow study of the carbohydrate metabolism. The differences are summarised as follows:

API 20 Strep kit

	MIA	K12
β-galactosidase	+	-
Alkaline phosphatase	-	+

API 50 CH

Glycerol	-	+ anaerobic
L-arabinose	+	-
α-methyl-D-mannoside	-	+ aerobic
Inulin	+	-
Glycogen	+	-
Xylitol	+	-
β-gentiobiose	+	-

Preferably, strains for use in the invention exhibit at least one, preferably at least three, more preferably at least six, and even more preferably all of the distinguishing biochemical characteristics of strain Mia.

Mia also exhibits stronger anti-MS, and in particular stronger anti-*S. mutans* activity than K12.

S. salivarius strain Mia is a BLIS-producing strain with activity against other bacteria, particularly streptococci, and more particularly MS, including *S. mutans*. *S. salivarius* strain Mia was deposited with Deutche Sammlung von Mikroorganismen Und Zellkulturen GmbH, Mascheroder Weg 1 b, D-38124, Braunschweig, Germany on 12 December 2001 and has been assigned Accession No. DSM 14685.

As noted above MS are considered the primary causative agents in dental caries with *S. mutans* being of particular significance. While BLIS-producing strains of *S. salivarius* active against streptococci have been reported previously, this is the first time that BLIS producing *S. salivarius* active against MS and *S. mutans* in particular, have been identified.

The *S. salivarius* strains of the invention exhibit broad spectrum antibacterial activity, particularly when grown on TSBCaYE agar media. The *S. salivarius* are therefore useful as antibacterial agents *per se* as well as therapeutically. In this context, "therapeutic" includes prophylactic treatment. Therapeutic uses include the treatment or prevention of microbial infections, especially streptococcal infections. The *salivarius'* of the invention are particularly suitable for use against MS and *S. mutans*. Conditions amenable to treatment with the strains or extracts of the invention include dental caries, sore throats, and bad breath.

The invention also relates to extracts obtainable from *salivaricin* A_2-producing strains of *S. salivarius* and especially from strains of the invention. These active extracts may similarly be used in therapeutic formulations and methods. Extracts can be obtained using known art protocols, conveniently by cell culture and centrifugation.

A "therapeutic formulation" is a formulation appropriate for administration of an *S. salivarius* strain or extract of the invention, to an individual in need of same, particularly a dental caries-susceptible individual. In general, therapeutic formulations of the invention are composed of an *S. salivarius* strain or extract of the invention and an acceptable carrier, diluent and/or excipient.

An "acceptable carrier, diluent and/or excipient" means a vehicle for delivery of a *S. salivarius* strain or extract of the invention, to the individual, in which the vehicle is compatible with bacterial cell viability, or activity of the extract. Acceptable carriers suitable for use in the administration of viable *S. salivarius* strains of the invention and extracts are well known to those skilled in the art. Suitable carriers are generally inert and can be either solid or liquid.

In one embodiment, the carrier is a pharmaceutically acceptable carrier. Pharmaceutically acceptable carriers suitable for use with the *S. salivarius* strains herein include, but are not limited to, water, buffered saline solutions (e.g., phosphate-buffered saline), pharmaceutically acceptable culture media (e.g. BACa, TSBCaYE agar), or other solutions which maintain the viability of the bacterium. Additionally, such pharmaceutically acceptable carriers may be aqueous or non-aqueous solutions, suspensions, and emulsions. A variety of pharmaceutically acceptable carriers suitable for oral administration of viable or lyophilized bacteria are well known in the art (see, for example, *Remington's Pharmaceutical Sciences*, 18th ed., Gennaro, ed., 1990, Mack Publishing Co., Easton, Pa., incorporated herein by reference; and the pharmaceutical composition LACTINEX™, a commercially available formulation for oral administration of viable lactobacilli). Suitable solid carriers known in the art include, for example, magnesium carbonate; magnesium stearate; celluloses; talc; sugars such as fructose, sucrose, mannitol, lactose; starches; flours; and skim milk, and similar edible powders, but are not limited thereto. Carriers for administration of extracts are similarly well known.

Typical diluents, by way of example, are: starches; lactose; mannitol; kaolin; calcium phosphate or sulphate; inorganic salts such as sodium chloride; and powdered sugars or celluloses.

The compositions may also include excipients such as tableting aids; resins; fillers; binders; lubricants; solvents; glidants; disintegrants; preservatives; buffers; flavourings; colourings; sweeteners; and fragrances as appropriate. A preferred excipient for tablet flowability and compactability is ProSolv™ (Penwest, NY, USA). A preferred sweetener is isomalt.

Typical binders include starch; gelatin; sugars such as lactose, fructose, and glucose; and the like. Natural and synthetic gums are also convenient, including acacia; alginates; methylcellulose; polyvinylpyrrolidine tragacanth; and the like. Polyethylene glycol; ethyl cellulose; and waxes can also serve as binders. A currently preferred binder is Emdex™ (Penwest, NY, USA).

Lubricants to prevent sticking to the die during formation include slippery solids such as talc, silica, magnesium and calcium stearate, polyethylene glycol, stearic acid and hydrogenated vegetable oils.

Disintegrators are substances which swell when wetted to break up the lozenge and release the *S. salivarius* or extract. The disintegrators include starches; clays; celluloses; algins and gums; more particularly corn and potato starches; methylcellulose; agar; bentonite; wood cellulose; cation exchange resins; alginic acid; guar gum; citrus pulp; carboxymethylcellulose; powdered sponge; and sodium lauryl sulfate.

The *S. salivarius* strains or extracts of the invention can be formulated in any of a variety of compositions suitable for oral administration. For example, the *S. salivarius* strains can be formulated for administration as a lyophil or cell paste prepared from a *S. salivarius* culture, or can be directly administered to the oral cavity. The strain or extract can also be administered in the form of a mouthwash, mouth rinse, toothpaste, mouthspray, gargle, capsule, lozenge, syrup, floss, chewing gum, or chewable tablet but the forms are not limited thereto.

Therapeutic formulations may include food, confectionary or drink. In one embodiment, the foodstuff or drink is a dairy product-based food or drink including by way of example, yoghurt, cheese, milk, milk power, milk biscuits, and flavoured milks. In the case of confectionary, the formulation can be a chewing gum such as described in WO 00/05972. One preferred formulation employs freeze dried *S. salivarius* of the invention in milk powder formulations in a manner similar to that previously reported for the preparation of Bifidus Milk Powder (Nagawa et al. (1988); J. Dairy Sci. 71:1777-1782).

One orally administrable formulation of *S. salivarius* is a blend of freeze dried *S. salivarius* strains with skim milk powder or the like which has been flavoured to enhance palatability.

Presently preferred orally administrable formulation of *S. salivarius*, or extracts of the invention are lozenges, chewable tablets, or capsules. Lozenges are particularly preferred. A suckable lozenge according to the invention comprises an *S. salivarius* strain or extract of the invention, isomalt and emdex. The lozenge may be prepared by direct compression, wet granulation, or dry granulation. The lozenges may be coated according to well known pharmaceutical practice.

The therapeutic formulation can additionally contain nutrients to maintain the viability of the bacterium in the formulation. As noted above, the formulation can also contain flavouring agents, colouring agents, fragrances, or other compounds which increase the palatability of the composition and/or enhance patient compliance without compromising the effectiveness of the formulation. Methods for preparation of formulations for oral administration are well known in the art (see, for example, Remington's Pharmaceutical Sciences, 18th ed., supra, incorporated herein by reference).

For general antimicrobial use, formulations may also be produced for other methods of administration including topically administrable formulations but not limited thereto.

K12 and active extracts thereof discussed above may similarly be prepared as above, including in the compositions and formulations discussed.

The formulations and compositions of the invention may further comprise one or more secondary antibacterial agents. These secondary agents may, for example, be antibiotics, or

other antibacterial agent or antibacterial producing microorganisms. Useful antibacterials include nisin, and other BLIS for example. Preferably, the secondary antibacterial agent is a BLIS or BLIS producing microorganism. The BLIS may be one or more of salivaricin A, A_1, A_2 and B. Other antibacterial microorganisms include known *S. salivarius* such as K12 and K30.

S. salivarius strains of the invention are primarily found on the tongue surface. Combinations with *S. salivarius* that grow in dental plaque such as TOVE-R (supra) would be useful.

The formulation and compositions of the invention may additionally comprise other anti-cariogenic agents, for example, xylitol, fluoride, Manuka honey, and tannins.

In the treatment of dental caries, *S. salivarius* strains or extracts of the invention can be administered to any dental caries-susceptible individual, usually an individual in which *S. mutans* or MS colonises the oral cavity such that the dental caries is caused at least in part by *S. mutans* and more commonly by MS.

The term "individual" as used herein includes humans, horses, dogs, cats, pigs, sheep, cattle, goats but is not limited thereto. Preferably, the individual is a human. The *S. salivarius* strains can be administered to the individual at any age, e.g. childhood, adolescence, or adulthood.

The *S. salivarius* of the invention or K12 can be orally administered in a variety of ways. For example, in the form of compositions or formulations discussed above, or as suspensions, sustained release formulas (e.g. an oral implant containing the *S. salivarius* strain) or lyophil powders. The *S. salivarius* strains can also be administered by direct application of a lyophil, culture, or cell paste to the teeth or tongue of the individual. Any mode of administration is suitable as long as the therapeutic formulation is applied to the oral cavity. In one embodiment, the *S. salivarius* or extracts are administered by applying directly to the teeth of the individual, e.g. by brushing and/or flossing.

In general, the amount of *S. salivarius* administered to the individual will be an amount effective for replacement of dental caries-causing MS strains, or at least S. *mutans* in the oral cavity of the host. "An amount effective for replacement of dental caries-causing MS strains

or at least *S. mutans* in the oral cavity of the host" means an amount effective for oral cavity colonisation by the *S. salivarius* strain, and significant reduction of the resident dental caries-causing *S. mutans* or MS strains (e.g. by competition between the bacteria for nutrients and/or by the production of BLIS by the *S. salivarius* strain).

The term "unit dose" when used in reference to a therapeutic formulation of the present invention refers to physically discrete units suitable as unitary dosage for the individual, each unit containing a predetermined quantity of active material (viable *S. salivarius* or active extract thereof) calculated to produce the desired therapeutic effect in association with the required diluent, carrier, or excipient.

Specific dosages can vary widely according to various individual variables including size, weight, age, disease severity (e.g. the tenacity and/or number of dental caries-causing resident MS) and responsiveness to therapy (e.g. the susceptibility of the individual's oral cavity to colonisation). Methods for determining the appropriate route of administration and dosage may be determined by the consumer as they deem appropriate, or on a case-by-case basis by an attending dentist or other clinician. Such determinations are routine to one of ordinary skill in the art (see for example, *Remington's Pharmaceutical Sciences*, 8th ed., Gennaro, ed., Mack Publishing Company, Easton, Pa., 1990).

In general, the number of *S. salivarius* administered to the individual will range from about 10^2 to 10^{15} bacteria, preferably from about 10^3 to 10^{14} bacteria, more preferably from about 10^5 to 10^{12} bacteria, normally about 10^9 to 10^{10} colony forming units (CFU) per dose. One lozenge formulation employs 3.8×10^9 CFU/ml.

Multiple doses of the *S. salivarius* strain can be administered to achieve oral cavity colonisation and replacement of the resident, dental caries-causing MS strains, particularly *S. mutans*, of the individual. The *S. salivarius* strain or extract may need to be administered to the patient once only or repeatedly. Repeat treatments may be once a month, once a week, once a day, twice a day, or as may otherwise be required. Conveniently, the administration may be effected as part of the patient's routine dental care, e.g. as a component of a lozenge, gum, toothpaste, floss, or mouthwash.

To facilitate colonisation, in one embodiment the treatment method of the invention includes a preliminary step of pre-treating the individual to at least reduce the normal microflora present in the oral cavity, including dental caries causing organisms. This pre-treatment comprises the step of administering an antimicrobial agent such as chlorhexidine, lactoperoxidase, green tea, or pineapple juice (freeze dried), but not limited thereto, or may follow a prescribed course of antibiotics such as penicillin, erythromycin, or amoxycillin administered to said individual. *S. salivarius* of the invention or *S. salivarius* K12 is then administered to the depopulated environment to repopulate same.

A currently preferred treatment protocol for dental caries comprises pre-treatment by brushing teeth with chlorhexidine gel for 2 to 5 days, preferably 3 days. A lozenge is administered 1-4 hours, preferably 2 hours after the gel. This is followed by administration of a further 2-5, preferably 3 lozenges through the day at intervals of 1-4 hours, preferably every 2 hours. This protocol is followed for 2-4 days to facilitate colonisation. For maintenance purposes 1, 2, or 3 lozenges, usually 1 to 2 lozenges are taken each day following ordinary tooth brushing. The regime is continued for as long as required.

Successful colonisation of the individual's oral cavity by the *S. salivarius* strain can be established by culturing the bacteria of the individual's oral cavity, and identifying the *S. salivarius* strain by, for example, BLIS production or other methods well known in the art for bacterial strain identification.

The methods and uses of the invention may further comprise the use of one or more secondary antibacterial agents, and/or anticariogenic agents as discussed above.

Where the term comprise, comprises, comprised or comprising are used in this specification, they are to be interpreted as specifying the presence of the stated features, integers, steps or components referred to, but not to preclude the presence or addition of one or more other features, integers, steps, components or groups thereof.

Various aspects of the invention will now be illustrated in a non-limiting way by reference to the following experimental section.

EXPERIMENTAL

Identification

Strain Mia was isolated from the oral cavity of a healthy adult human subject. It grows on Mitis salivarius agar at 37°C, 5% CO_2 with morphology typical of *S. salivarius* as follows:

Colony shape and size: round, 1-2 mm in diameter
Margin (edge): entire (smooth)
Elevation: convex
Colour: blue
Texture: mucoid

On Blood agar [Columbia Agar Base (GIBCO) with 5% human blood] at 37°C, 5% CO_2 it is not haemolytic, and exhibits the following morphology:

Colony shape and size: round , <1 mm in diameter
Margin (edge): entire (smooth)
Elevation: convex
Colour: white
Texture: mucoid

When cultivated on either Blood agar or on Trypticase soy broth (BBL) + Davis agar 1.5% supplemented with 0.1% calcium carbonate the bacterial growth appears relatively more firmly adherent to the agar surface than is typical of most *S. salivarius*. The API 20 Strep Identification code for the strain is 5050451, which corresponds to *Streptococcus salivarius* (98.4% identity).

16s rRNA Sequence Analysis with reference to the GENEBANK database established the strain to be *Streptococcus salivarius* (99.9% homology).

Biochemical Characterization

Biochemical characterization of *S. salivarius* MIA was conducted using the API 20 Strep kit (bioMérieux) and API 50 CH (bioMérieux) which allows the study of the carbohydrate metabolism.

The API 20 Strep results are as follows:

Acetone production	positive
Hydrolysis	negative
β-glucosidase	positive
Pyrrolidonyl arylamidase	negative
α-galactosidase	negative
β-gluuronidase	negative
β-galactosidase	positive
alkaline phosphatase	negative
Leucine arylamidase	positive
Arginine dihyrolase	negative
Ribose	negative
L-arabinose	negative
Mannitol	negative
Sorbitol	negative
Lactose	positive
Trehalose	positive
Inulin	negative
Raffinose	positive
Starch	weak positive
Glycogen	negative
β-haemolytic	negative

The API 50 CH results are as follows:

Glycerol	negative
Erythritol	negative
D-Arabinose	negative
L-Arabinose	positive (anaerobic only)
Ribose	negative
D-Xylose	negative
Adonitol	negative
B Methyl-xyloside	negative
Galactose	positive
D-Glucose	positive
D-Fructose	positive
D-Mannose	positive
L-Sorbose	negative
Rhamnose	negative
Dulcitol	negative
Inositol	negative
Mannitol	negative
Sorbitol	negative
α Methyl-D-mannoside	negative
α Methyl-D-glucoside	positive (anaerobic only)
N-Acetyl glucosamine	positive
Amygdaline	positive
Arbutin	positive
Esculin	positive

Salicin	positive
Cellobiose	positive
Maltose	positive
Lactose	positive
Melibiose	positive (aerobic only)
Saccharose	positive
Trehalose	positive
Inulin	positive (anaerobic only)
Melezitose	negative
D-Raffinose	positive
Amidon	positive
Glycogen	positive (anaerobic only)
Xylitol	positive (aerobic only)
β Gentiobiose	positive
D-Turanose	negative
D-Lyxose	negative
D-Tagatose	positive (anaerobic only)
D-Fucose	negative
L-Fucose	negative
D-Arabitol	negative
L-Arabitol	negative
Gluconate	negative
2 ceto-gluconate	negative
5 ceto-gluconate	negative

S. salivarius MIA is urease positive when grown on Christenens urea agar.

Inhibitory Activity

Deferred Antagonism test for BLIS Activity

When tested for bacteriocin-like inhibitory substance (BLIS) production on the Blood agar-based medium, Columbia agar Base (GIBCO) + 0.1% $CaCO_3$ +5% human blood (BACa) according to the deferred antagonism test of Tagg and Bannister the P-type designation of strain Mia is 677.

P-type of *S. salivarius* MIA

Producer typing (P-type) describes the antimicrobial activity of bacteria against a set of standard indicators. The procedure was first described by Tagg and Bannister (J. Med. Microbiol. 1979; 12: 397-411).

For P-typing *S. salivarius* MIA was grown as a diametric streak culture on a Blood agar + 0.1% calcium carbonate plate or Trypticase soy-yeast extract-calcium carbonate agar (Trypticase soy broth, 30; yeast extract, 20 g; calcium carbonate, 2.5 g; agar, 15 g; distilled

water, 1000 ml), incubated at 37°C, 5% CO_2 for 18 h. The growth was then removed and the surface of the plate sterilised with chloroform. Nine indicator strains were then cross-inoculated. After incubation at 37°C, 5% CO_2 for 18 h inhibition of growth was recorded. The inhibition patterns were recorded in a code form by considering the nine indicators as three triplets (eg, I1, I2, I3, I4, I5, I6; I7, I8, I9). Positive reactions against each indicator were given a score of 4, 2 or 1 depending on whether the indicator was, respectively, the first, second or third member of the triplet. No inhibition was recorded as zero. The total score of each triplet thus specified uniquely the reactions against the three indicators. The complete P-type code is written as a sequence of three numbers, consecutively defining the reactions within the three triplets.

S. salivarius MIA has a 677 P-type on Blood agar + calcium carbonate, and a 777 P-type on Trypticase soy-yeast extract-calcium carbonate agar.

This corresponds to inhibition of all 9 bacteria in the panel of 9 indicator strains except for indicator 3. This pattern is typical of that given by salivaricin A- producing *S. salivarius* such as strain 20P3 (Ross et al Appl. Envir. Microbiol. 1993; 59;2014). However, when tested on trypticase soy broth (BBL) +Davis Agar (1.5%) + 0.25% calcium carbonate + yeast extract (2%) [TSBCaYE] the P-type is 777 (i.e. all 9 indicators are inhibited). Associated with this increased activity against indicator 3 there is also additional activity against a variety of other bacteria when tested as indicators (Table 1).

Table 1: Antimicrobial activity of strain Mia on BACa and TSCaYE media

Bacteria		Susceptibility when tested on BACa	TSBCaYE
Clostridium sporogenes		+	+
Clostridium perfringens		+	+
Actinomyces viscosus	T14	+	+
	M100	+	+
Actinomyces naeslundii	10301	+	+
Streptococcus sobrinus	OMZ176	-	+
Streptococcus mutans	ATCC10449	-	+
	OMZ175	-	+
	633K	-	+
	H7	-	+
	13M	-	+

	E49	-	+
	K58	-	+
	K60	-	+
	M46	-	+
	MUTI	-	+
	MUTII	-	+
Corynebacterium diphtheriae gravis		-	+
Enterococcus faecalis	98	-	+
Enterococcus hirae	*9790*	-	+
Streptococcus agalactiae 211B		+	+
	P3	+	+
Streptococcus uberis	I4	+	+
	D618	+	+
Lactobacillus brevis		-	+
Lactobacillus casei		-	+
Lactobacillus acidophilus		+	+
Streptococcus pneumoniae PK2		+	+
	PK34	+	+
Moraxella catarrhalis	4	-	+
	K	-	+
Listeria monocytogenes	10403	+	+
Listeria monocytogenes	215	+	+
Stomatococcus mucilagenosus Coup		+	+
Neisseria gonnorhoea		-	+
Neisseria meningitidis		-	+
Neisseria lactamica		-	+
Haemophilus influenzae	30	-	+
	37	-	+
Staphylococcus saprophyticus 7292		-	+
Staphylococcus cohnii 20260		-	+

Deferred Antagonism Test of Anti-S. mutans Activity

The anti-S. mutans spectrum of inhibitory activity of salivaricin A_2 producer strains was established by use of a deferred antagonism test, essentially as described by Tagg and Bannister [J. Med. Microbiol. 1979;12:397] . In brief, a 1-cm wide diametric streak culture of each producer strain was inoculated onto TSBCa and BACa media either with or without yeast extract (YE) supplementation. Following incubation in an anaerobic atmosphere for 24 hours at 37°C the macroscopic cell growth was removed with a glass slide and residual cells on the agar surface were killed by exposure to chloroform vapours for 30 minutes. The agar surface was then aired for 30 minutes and the indicator strained inoculated from 18 hour Todd Hewitt Broth (THB) cultures across the line of the original streak culture with use of cotton swabs. After incubation for 18 hours in 5% (v/v) CO_2 at 37°C the extent of inhibition of each indicator strain was recorded.

TSBCaYE medium (per 500 ml)

Trypticase soy broth (BBL)	15 g
Davis Agar	7.5 g
Yeast Extract (Difco)	10 g
$CaCO_3$	1.25 g

BACaYE medium (per 500 ml)

Columbia Blood Agar base (Difco)	22 g
$CaCO_3$	0.5 g
Yeast Extract (Difco)	10

The results are shown in Table 2.

Table 2: Comparison of anti-*S. mutans* activity of *S. salivarius* strains Mia and K-12 in deferred antagonism tests on BACa or TSBCa when supplemented with yeast extract

Producer strain	Salivaricin status	Test medium	Inhibition of *S. mutans* strain								
			ATCC 10449	OMZ 175	H7	13M	K-56	K-60	M-46	MutI	MutII
Mia	A2	BaCa	+++	+++	++	-	-	-	++	-	-
Mia		BaCaYE	+++	+++	++	++	++	++	++	++	++
Mia		TSBCa	++	+++	+	-	-	-	+	+	-
Mia		TSBCaYE	+++	+++	++	+	+	+	++	+	+
K-12	A2 + B	BaCa	++	++	-	-	-	+	+	-	-
K-12		BaCaYE	+++	+++	+++	++	++	++	+++	++	++
K-12		TSBCa	++	++	-	-	-	-	++	-	-
K-12		TSBCaYE	++	++	++	-	+	+	++	+	-

WO 03/070919 PCT/NZ03/00031

Production of inhibitory activity in saliva fluid by strain Mia

Saliva fluid was prepared as follows:

Stimulated saliva was collected, heated at 60°C for 0.5 hr then centrifuged at 12000 x *g* for 10 min. The supernatant was supplemented with 0.5% maltose, 0.5% $CaCO_3$ and 0.25 µg/ml cysteine (final concentrations).

The supplemented supernatant was used as a basal fluid medium for growth of strain Mia at 37°C. The inoculum was from an 18 h TSBYECa culture at a ratio of 100µl per 2 ml supernatant. Different aliquots were supplemented as indicated.

After 24 h incubation in an anaerobic atmosphere samples of the saliva cultures were tested for inhibitory activity against the indicators OMZ175, MutII, and I1 either neat or following 10x concentration by rotary evaporation. The10x concentrated supernatant from the culture grown in saliva supplemented with Maltose, Cysteine and $CaCO_3$ had inhibitory activity against *S. mutans* strain OMZ175 as shown in the table below. *S. salivarius* Mia therefore produces anti-*S. mutans* activity when grown in saliva.

Assay of inhibitory activity

Inhibitory activity was determined by end-point titration using a surface spot method in which 20 µL drops of two-fold serial dilutions of the test preparation in saline were spotted onto the surface of Blood Agar medium. When the drops had dried into the agar, the surface of the medium was sterilized by exposure to chloroform vapour for 30 minutes, aired and then inoculated by swabbing evenly from an 18 hour THB culture of indicator strain. Following incubation, the titre of inhibitory activity in Arbitrary Units (AU) per mL was taken to be the reciprocal of the highest dilution to show definite inhibitory activity. The results are shown in Table 3.

Table 3: Production of inhibitory activity in saliva fluid by strain Mia

Supplement	Activity (AU/ml) against indicator of supernatant of saliva fluid culture:					
	Unconcentrated			Concentrated x 10 speedvac		
	I1	OMZ175	Mut II	I1	OMZ175	Mut II
Saliva only	0	0	0	1	0	0
M	0	0	0	1	0	0
M, Cy	0	0	0	1	0	0
M, Ca	2	0	0	2	0	0
Cy, Ca	0	0	0	0	0	0
M, Cy, Ca	4	0	0	4	2	0

M= 0.5% maltose; Cy = 0.5% cysteine; Ca = 0.1% $CaCO_3$

In vivo activity of *S. salivarius* MIA against MS.

One subject brushed their teeth with 2% chlorhexidine gel for 2 minutes on the first day and then sucked a tablet containing 3.8 x 10^9 colony forming units of *S. salivarius* MIA, two hours after the chlorhexidine treatment and then a further three tablets at two hourly intervals. On the second day the subject repeated the same procedure as for day one. The subject for the remaining 25 days of the trial sucked one tablet after brushing their teeth with a commercial toothpaste, in the morning and at night.

Control subjects cleaned their teeth once a day for three days with 2% chlorhexidine gel and for the remaining time brushed their teeth with a commercial toothpaste.

Saliva samples were collected from all subjects prior to starting the trial and at intervals throughout the trial to determine number of MS (colony forming units (cfu) per ml of saliva). The saliva sample was diluted in sterile saline and spiral plated onto Mutans selective agar, and the plates incubated under anaerobic conditions at 37°C for 2 days. The number of *S. salivarius* MIA in the saliva sample was also determined for the subject taking the tablets. The diluted saliva sample is spiral plated onto Mitis-salivarius agar and the plates are incubated at 37°C, 5% CO_2 for 18-24 hours. The number of *S. salivarius* colonies are then counted. To determine the percentage of colonization with *S. salivarius* MIA the following

protocol is used. Fresh THB cultures of *Micrococcus luteus* and *S. mutans* OMZ175 are spread separately on the top of a Blood agar/calcium plates. *S. salivarius* colonies are then picked into both plates. The plates are incubated at 37°C, 5% CO_2 for 18-24 hours. *S. salivarius* MIA colonies produce zones of inhibition around the stab cultures on both plates. Percentage colonization is determined as the number of positive colonies divided by the total number of colonies picked.

Brushing teeth with a 2% chlorhexidine gel resulted in a 1.7-2.4 log reduction in MS counts in both the control (Table 4) and the colonizing subject (Table 5). The MS cell counts in the control subjects increased to pre-treatment levels, in the control subjects, between one to six days after brushing with the gel. The test subject was 100% colonized after the pre-treatment with the gel and remained highly colonized for the remaining trial period (Table 5). Numbers of MS were still 1.7 log lower than pre-treatment levels at 27 days. This shows that colonization with *S. salivarius* MIA is capable of preventing the re-establishment of high levels of MS.

Table 4. The effect of 2% chlorhexidine gel on the levels of MS in the control subjects

Time (days)	Number of MS (cfu/ml of saliva)			
	Subject 1	Subject 2	Subject 3	Subject 4
Pre-treatment	1.4×10^4	1.3×10^5	5.8×10^3	9.9×10^3
1	2.2×10^3	1.2×10^3	1.5×10^2	4.3×10^1
2	3.0×10^2	ns	$< 10^2$	4.0×10^3
5	4.5×10^2	3.3×10^4	2.3×10^3	3.7×10^4
8	8.4×10^4	ns	5.1×10^4	ns
33	2.7×10^3	ns	3.5×10^4	2.0×10^3

Table 5. Effect of colonization with *S. salivarius* MIA on MS

Time (days)	% colonization with *S. salivarius* MIA	Number of MS (cfu/ml of saliva)
Pre-treatment	0	5.8×10^4
1		2.5×10^2
2		1.0×10^2
3		4.0×10^2
6	100	2.0×10^2
13	98	2.0×10^2
16	100	6.0×10^2
20	100	8.0×10^2
23	95	2.6×10^3
27	100	1.0×10^3

Preparation of anti-MS active extract

One hundred ml of molten Trypticase Soy agar containing 2% yeast extract and 0.25% calcium carbonate was poured into a 1 L schott bottle. One ml of an overnight culture of *S. salivarius* MIA, grown in Todd Hewitt broth at 37°C, in 5% CO_2 in air, was added to the bottle. The culture was incubated anaerobically at 37°C for 18-24 hours. One hundred ml of Trypticase Soy broth containing 2% yeast extract and 0.25% calcium carbonate was added to the bottle, which had been preincubated under anaerobic conditions. The culture was then incubated for a further 24 hours anaerobically at 37°C. The broth was centrifuged to remove the bacterial cells and then ammonium sulphate was added to 50% (w/v) and incubated at 4°C for 18 hours. The sample was then centrifuged and the pellet resuspended in 1 ml of milli-Q water. Anti-MS activity of the sample was then tested using a well diffusion assay in Blood agar plates. Fifty µl of the sample is added to each well and air-dried. The plates were then

chloroform treated. An overnight culture of the indicator strain was spread over the top of the plate and incubated at 37°C, 5% CO_2 in air, for 18-24 hours.

Zones of inhibition (distance from edge of the well to edge of inhibition of cell growth) were recorded against all the indicator strains (Table 6).

Table 6. Well diffusion assay of *S. salivarius* MIA extract

Indicator strain	Zone of inhibition (mm)
Micrococcus luteus T18	12
Streptococcus anginosus T29	2
Streptococcus mutans H7	2
Streptococcus mutans 10449	3
Streptococcus mutans MutII	2
Streptococcus mutans 0MZ175	2

DOSAGE FORM EXAMPLE

	Lozenge
Ingredients	**Per 945 mg lozenge**
S. salivarius	3.8×10^9 CFU (freeze dried)
Isomalt	600mg
Emdex™	150mg
ProSolv HD™	50mg
Magnesium stearate	15mg
Flavour	10mg

The ingredients are blended and tablets produced using dry compression.

INDUSTRIAL APPLICATION

The results above demonstrate the antibacterial effect of *S. salivarius* strains, particularly strain Mia against a broad spectrum of microorganisms, particularly streptococci. These strains are the first BLIS producing *S. salivarius* to be identified which have activity against MS, and more particularly *S. mutans*. The strains and related active extracts herein therefore have application in methods of therapeutically treating individuals against the harmful effects of streptococcus infection, especially in the oral cavity. These methods include treatment of

dental caries in which MS or *S. mutans* are the primary causative agent. The *S. salivarius* extracts and compositions of the invention also have application in the treatment of bad breath and sore throats.

It will be appreciated that the above description is provided by way of example only and that variations in both the materials and techniques used which are known to those persons skilled in the art are contemplated.

CLAIMS:

1. A biologically pure culture of a *Streptococcus salivarius* strain which is a Salivaricin A_2 producer and which exhibits anti-MS activity with the proviso that the strain is not *S. salivarius* K12 (K12).

2. A biologically pure culture of a *Streptococcus salivarius* strain which is a Salivaricin A_2 producer, exhibits anti-MS activity, and for carbohydrate metabolism is positive for at least one of L-arabinose, inulin, glycogen, xylitol, and β-gentiobiose use, or β-galactosidase production; and/or is negative for at least one of glycerol, α-methyl-D-mannoside use, or alkaline phosphatase production.

3. A biologically pure culture as claimed in claim 2 wherein the strain is positive for each of L-arabinose, inulin, glycogen, xylitol and β-gentiobiose use or β-galactosidase production; and/or is negative for each of glycerol, α-methyl-D-mannoside use, or alkaline phosphatase production.

4. A biologically pure culture of *Streptococcus salivarius* strain Mia on deposit at Deutsche Sammlung von Mikroorganismen Und Zellkulturen GmbH, Mascheroder Weg 1 b, D-38124, Braunschweig, Germany, Accession No. DSM 14685, or a culture having the identifying characteristics thereof.

5. An extract obtainable from Salivaricin A_2-producing strains of *S. salivarius* which extract has anti-MS activity.

6. An extract as claimed in claim 5 which has anti-*S. mutans* activity.

7. An extract as claimed in claim 5 or claim 6 which is obtainable from *S. salivarius* as claimed in any one of claims 1 to 4.

8. An extract as claimed in claim 5 or claim 6 which is obtainable from *S. salivarius* K12.

9. An antibacterial composition which includes an *S. salivarius* as claimed in any one of claims 1 to 4 or an extract as claimed in any one of claims 5 to 8.

10. A therapeutic formulation comprising an *S. salivarius* as claimed in any one of claims 1 to 4 or an extract as claimed in any one of claims 5 to 8, together with a diluent, carrier and/or excipient.

11. A composition or formulation as claimed in claim 9 or claim 10 which further comprises one or more secondary antibacterial agents.

12. A composition or formulation as claimed in claim 11 wherein the secondary antibacterial agent is selected from nisin, BLIS and BLIS producing microorganisms.

13. A composition or formulation as claimed in claim 12 wherein the BLIS is one or more BLIS selected from salivaricin A, A_1, A_2 and B.

14. A composition or formulation as claimed in claim 12 wherein the BLIS producing microorganism is K12 and/or K30.

15. A composition or formulation as claimed in any one of claims 9 to 14 which further comprises one or more secondary anti-cariogenic agents.

16. A composition or formulation as claimed in claim 15 wherein the secondary anti-cariogenic agent is selected from xylitol, fluoride, Manuka honey and tannin.

17. A composition or formulation as claimed in any one of claims 9 to 16 which is an orally administerable composition or formulation.

18. A composition or formulation as claimed in any one of claims 9 to 17 wherein the compositions or formulations are included in a food or drink.

19. A composition or formulation as claimed in claim 18 wherein said food or drink is a dairy based food or drink.

20. A composition or formulation as claimed in claim 19 wherein said food or drink is milk powder, milk biscuits, milk, flavoured milk, yoghurt or cheese.

21. A composition or formulation as claimed in any one of claims 9 to 17 wherein the compositions or formulations are in the form of medicaments, lozenges or confectionaries.

22. A composition or formulation as claimed in claim 21 which is in the form of a lozenge.

23. A composition or formulation as claimed in claim 21 which is in a mouthwash, mouth rinse, toothpaste, gargle, syrup, mouth spray, capsule, floss, chewing gum, or tablet.

24. A composition or formulation as claimed in any one of claims 17 to 23 which is in unit dosage form.

25. A composition or formulation as claimed in claim 24 which contains from about 10^5 to 10^{12}, preferably 10^9 to 10^{10} CFU of *S. salivarius* per dose.

26. A method for at least inhibiting the growth of bacteria sensitive to *S. salivarius* as claimed in any one of claims 1 to 4, the method comprising contacting the sensitive bacteria with an inhibitory effective amount of an *S. salivarius* as claimed in any one of claims 1 to 4, an extract as claimed in any one of claims 5 to 8, or a composition or formulation as claimed in any one of claims 9 to 25.

27. A method as claimed in claim 26 wherein the sensitive bacteria are MS.

28. A method as claimed in claim 27 wherein the sensitive bacteria are *S. mutans*.

29. A method for at least inhibiting the growth of MS or *S. mutans* bacteria, the method comprising contacting the MS or *S. mutans* with an inhibitory effective amount of:

(i) an *S. salivarius*, extract, composition or formulation as claimed in any one of claims 1 to 25; or

(ii) *S. salivarius* K12, or an anti-MS or anti-*S. mutans* active extract therefrom, or a composition or formulation comprising K12 or an active extract therefrom.

30. A method of therapeutic treatment of dental caries caused at least in part by *S. mutans* in an individual in need thereof, the method comprising administering to said individual:

(i) an *S. salivarius*, extract, composition or formulation as claimed in any one of claims 1 to 25; or

(ii) *S. salivarius* K12 or an anti-*S. mutans* active extract therefrom, or a composition or formulation comprising K12 or an active extract therefrom,

in an amount effective to at least inhibit growth of *S. mutans* in the oral cavity of the individual.

31. A method of controlling the incidence or severity of dental caries comprising introducing into the oral cavity of an individual susceptible to dental caries, a dental caries controlling amount of an *S. salivarius*, extract, composition or formulation as claimed in any one of claims 1 to 25.

32. A method as claimed in claim 31 wherein the dental caries is caused by MS.

33. A method of controlling the incidence or severity of dental caries caused by MS, the method comprising introducing into the oral cavity of an individual susceptible to dental caries, a dental caries controlling amount of *S. salivarius* K12, an anti-MS active extract therefrom, or a composition or formulation containing same.

34. A method as claimed in any one of claims 26 to 33 wherein the *S. salivarius* or extract is administered as part of a food, drink or nutraceutical.

35. A method as claimed in any one of claims 26 to 33 wherein the *S. salivarius* or extract is administered in a composition or formulation as claimed in any one of claims 9 to 25.

36. A method as claimed in any one of claims 26 to 35 which includes the preliminary step of pre-treating the individual to at least reduce the normal microflora already present.

37. A method as claimed in claim 36 wherein the pre-treatment is effected using an antimicrobial or antibiotic.

38. A method as claimed in claim 37 wherein the antimicrobial is chlorhexidene.

39. A method of controlling the incidence of severity of dental caries comprising the steps of:

(a) administering to said patient an amount of an antibiotic or antimicrobial effective to reduce the normal microflora including dental caries causing organisms present; and

(b) administering to the resulting bacterially depopulated environment, an *S. salivarius*, as claimed in any one of claims 1 to 4, or a composition or formulation containing same to repopulate said environment.

40. The use of *S. salivarius* as claimed in any one of claims 1 to 4, or an extract as claimed in any one of claims 5 to 8 in the preparation of a composition or formulation for use in at least inhibiting the growth of bacteria sensitive to *S. salivarius* as claimed in any one of claims 1 to 4.

41. The use of *S. salivarius* as claimed in any one of claims 1 to 4, or an extract as claimed in any one of claims 5 to 8, or K12, or an active anti-*S. mutans* extract therefrom in the preparation of a composition or formulation for use in at least inhibiting the growth of *S. mutans* bacteria.

42. The use of *S. salivarius* as claimed in any one of claims 1 to 4, or an extract as claimed in any one of claims 5 to 8, or K12, or an active anti-*S. mutans* extract therefrom in the preparation of a composition or formulation for use in at least inhibiting the growth of MS bacteria.

43. The use of *S. salivarius* as claimed in any one of claims 1 to 4, or an extract as claimed in any one of claims 5 to 8, or K12, or an active anti-*S. mutans* extract therefrom in the preparation of a composition or formulation for use in prophylactically or therapeutically treating dental caries caused at least in part by *S. mutans*.

44. The use as claimed in claim 37 wherein the dental caries is caused by MS.

45. The use of *S. salivarius* as claimed in any one of claims 1 to 4, or an extract as claimed in any one of claims 5 to 8 in the preparation of a composition or formulation for use in controlling the incidence and severity of dental caries.

C. Additional Indications (continued)

Mia: DSMZ No. DSM 14685

AUSTRALIA

The applicant hereby gives notice that the furnishing of a sample of a microorganism shall only be effected prior to grant of a patent, or prior to the lapsing, refusal or withdrawal of the application, to a person who is a skilled addressee without an interest in the invention (Regulation 3.25(3) of the Australian Patents Regulations.

CANADA

The applicant hereby requests that, until either a Canadian patent has been issued on the basis of the application or the application has been refused or abandoned and no longer subject to reinstatement, or is withdrawn, the furnishing of a sample of deposited biological material referred to in the application only be effected to an independent expert nominated by the Commissioner of Patents.

DENMARK

The applicant hereby requests that, until the application has been laid open to public inspection (by the Danish Patent and Trademark Office), or has been finally decided upon by the Danish Patent and Trademark Office without having been laid open to public inspection, the furnishing of a sample shall only be effected to an expert in the art.

EUROPEAN PATENT

In respect of those designations in which a European Patent is sought a sample of the deposited microrganism will be made available until the publication of the mention of the grant of the European patent or until the date on which the application has been refused or withdrawn or is deemed to be withdrawn, only by the issue of such a sample to an expert nominated by the person requesting the sample (Rule 28(4) EPC).

FINLAND

The applicant hereby requests that, until the application has been laid open to public inspection (by the National Board of Patents and Registration), or has been finally decided upon by the National Board of Patents and Registration without having been laid open to public inspection, the furnishing of a sample shall only be effected to an expert in the art.

FRANCE

The applicant hereby requests that, until the publication of the grant of the patent, the withdrawal or refusal of the application, the deposited culture shall only be accessible to an expert designated by the applicant.

ICELAND
The applicant hereby requests that, until a patent has been granted or a final decision taken by the Icelandic Patent Office concerning the application which has not resulted in a patent, the furnishing of a sample shall only be effected to an expert in the art.

IRELAND
The applicant hereby requests that, until the preparations for publication of the patent application have been completed by the Comptroller, a sample of the microorganism should be made available only to an expert.

NETHERLANDS
The applicant hereby requests that until the date of grant of a patent or date on which the application is refused or withdrawn or lapsed, the microorganism shall be made available as provided in Rule 31F(1) of the Patent Rules only by issue of a sample to an expert.

NORWAY
The applicant hereby requests that, until the application has been laid open to public inspection (by the Norwegian Patent Office), or has been finally decided upon by the Norwegian Patent Office without having been laid open to public inspection, the furnishing of a sample shall only be effected to an expert in the art.

SINGAPORE
The applicant hereby requests that the furnishing of a sample of a microorganism shall only be made available to an expert.

SWEDEN
The applicant hereby requests that, until the application has been laid open for public inspection (by the Swedish Patent Office), or has been finally decided upon by the Swedish Patent Office without having been laid open to public inspection, the furnishing of a sample shall only be effected to an expert in the art.

UNITED KINGDOM
The applicant hereby requests that the furnishing of a sample of a microorganism shall only be made available to an expert.

OTHER NOMINATED DESIGNATIONS
Where such provisions exists, the applicant hereby requests that, until the publication or grant of a patent, the withdrawal or refusal of the application, the deposited culture shall only be effected to an expert in the art.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ03/00031

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. [7]: C12N 1/20, A61K 35/74, A61P 1/02, A61P 31/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPIDS, MEDLINE, CA: salivaricin, salivarius, oral, enamel, cary, caries, decay, antibiotic, bacteriocin, mutans, streptococcus, tooth

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 01/27143 A1 (BLIS TECHNOLOGIES LIMITED *et al*) 19 April 2001 whole of document	1-3, 5-45
X	Tanzer JM *et al*, "Competitive Displacement of Mutans Streptococci and Inhibition of Tooth Decay by *Streptococcus salivarius* TOVE-R", *Infection and Immunity*, 1985, 48(1):44-50 whole of document	1-10, 17, 24-33, 35, 40-45
X	Tanzer JM *et al*, "Inhibition of Ecological Emergance of Mutans Streptococci Naturally Transmitted between Rats and Consequent Caries Inhibition by *Streptococcus salivarius* TOVE-R Infection", *Infection and Immunity*, 1985, 49(1):76-83 whole of document	1-10, 17, 24-33, 35, 40-45

[X] Further documents are listed in the continuation of Box C [X] See patent family annex

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
15 May 2003	21 MAY 2003
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200, WODEN ACT 2606, AUSTRALIA E-mail address: pct@ipaustralia.gov.au Facsimile No. (02) 6285 3929	Authorized officer **GARETH COOK** Telephone No : (02) 6283 2541

INTERNATIONAL SEARCH REPORT

International application No.
PCT/NZ03/00031

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	Dempster RP *et al*, "The production of bacteriocin-like substances by the oral bacterium *Streptococcus salivarius*", *Archives of Oral Biology*, 1982, 27:151-157 whole of document	1-5, 7-9, 26, 27, 40, 42
X	EP 524 732 A2 (Matsushiro) 27 January 1993 whole of document	1-4, 9, 10, 17-45

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/NZ03/00031

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report		Patent Family Member					
WO	01/27143	AU	79793/00	CA	2 363 713	NO	200127143
		BR	200014740	EP	1 169 340		
EP	524 732	CA	2 072 493	JP	50 04927	US	5 468 479

END OF ANNEX